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Development and Application of a Risk Assessment Tool for Aquatic Invasive Species in the International Rainy-Lake of the Woods Basin, United States and Canada

Open-File Report 2022–1070

U.S. Department of the Interior
U.S. Geological Survey

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By Amanda H. Bell, Leon R. Katona, and Nicole M. Vellequette

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U.S. Geological Survey, 2012, NAS—Nonindigenous Aquatic Species: U.S. Geological Survey database, https://nas.er.usgs.gov/.

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Contents

Figures

Tables

Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8×°C)+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

Abbreviations

BISON	Biodiversity Information Serving Our Nation
GLANSIS	Great Lakes Aquatic Nonindigenous Species Information System
IJC	International Joint Commission
NAS	Nonindigenous Aquatic Species

Development and Application of a Risk Assessment Tool for Aquatic Invasive Species in the International Rainy-Lake of the Woods Basin, United States and Canada

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Abstract

The Rainy-Lake of the Woods Basin covers 70,000 square kilometers in mid-central North America and is contained within the Provinces of Ontario and Manitoba in Canada and the State of Minnesota in the United States. This basin contains natural wilderness areas, national parks, and thousands of lakes that bring outdoor enthusiasts from around the world for hunting, fishing, backpacking, boating, and other forms of recreation. However, trade, commerce, visitors, and wildlife can inadvertently transport hitchhiking exotic invasive species that affect the functioning of natural systems by displacing native organisms, introducing diseases, and modifying predator/prey relations. In cooperation with the International Joint Commission, the U.S. Geological Survey evaluated the aquatic invasive species that pose a possible threat to North America. The outcome of this project is a set of lists of invasive species that have traits amenable or proximity to the Rainy-Lake of the Woods Basin. These lists can be referenced to further evaluate known and potential nonindigenous invasive species. The lists were derived by evaluating more than 1,500 species from several online sources including Non-Indigenous Aquatic Species, Great Lakes Aquatic Nonindigenous Species Information System, Biodiversity Information Serving Our Nation, and other State, Provincial, and Federal lists in the United States and Canada. The purpose of these lists is to be a coarse filter to determine which species pose the greatest risk to the Rainy-Lake of the Woods Basin. Using this filter, seven categories of risk assessment priorities were developed: Very High-Approaching, Very High-Present, High-Approaching, High-Present, Moderate, Low, and Native. These categories can be used by the International Rainy-Lake of the Woods Multi-Agency Arrangement Aquatic Invasive Species Subcommittee to prioritize which species will be evaluated further focusing on five risk factors: arrival risk, vulnerability assessment, ecological impact, socioeconomic impact, and beneficial impact. Based on proximity, ease of transport or introduction, and known impact to Rainy-Lake of the Woods or other impacted ecosystems, this project identified the following 10 species that could be prioritized first for risk evaluations: *Bythotrephes longimanus* (spiny waterflea), *Faxonius rusticus* (rusty crayfish), *Neogobius melanostomus* (round goby), *Dreissena polymorpha* (zebra mussel), *Bithynia tentaculata* (mud Bithynia or faucet snail), *Potamopyrgus antipodarum* (New Zealand mud snail), *Butomus umbellatus* (flowering rush), *Nitellopsis obtusa* (starry stonewort), *Myriophyllum spicatum* (Eurasian watermilfoil), and *Phragmites australis australis* (common reed).

Introduction

The Rainy-Lake of the Woods Basin covers 70,000 square kilometers in mid-central North America and is contained within the Provinces of Ontario and Manitoba in Canada and the State of Minnesota in the United States. This basin contains natural wilderness areas, national parks, and thousands of lakes that bring outdoor enthusiasts from around the world for hunting, fishing, backpacking, boating, and other forms of recreation. However, trade, commerce, visitors, and wildlife can inadvertently transport hitchhiking exotic invasive species that upset the functioning of natural systems by displacing native organisms, introducing diseases, and modifying predator/prey relationships. The International Rainy-Lake of the Woods Multi-Agency Arrangement Aquatic Invasive Species Subcommittee requested the U.S. Geological Survey identify the 10 most undesirable aquatic invasive species for the Rainy-Lake of the Woods Basin. The document describes the identification and prioritization of the 10 most probable aquatic invasive species that pose a threat to the Rainy-Lake of the Woods Basin.

Development of Lists and Ranking of Species

As per the Interagency Agreement between the International Joint Commission (IJC) and U.S. Geological Survey, a list of current and potential nonindigenous species to North America was developed totaling more than 1,500 species. Each species was entered into a Microsoft

Access database and investigated on multiple publicly available websites with the primary sources including Nonindigenous Aquatic Species (NAS), Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS), and Biodiversity Information Serving Our Nation (BISON) (U.S. Geological Survey, 2012, 2019; National Oceanic and Atmospheric Administration, 2019). Information for each species was recorded including continent of origin, first year of reported collection, means of introduction/transportation/spread, nonindigenous category, and establishment status. Based on reported collections, the proximity and native statuses of the species were categorized as being reported in or native to the Rainy-Lake of the Woods Basin, the Great Lakes Basin, or the Region (approximately 800-kilometer radius from Rainy-Lake of the Woods Basin; fig. 1).

A detailed schematic for the categorization process is shown in figure 2. The risk evaluation priority was divided into seven categories: Very High-Approaching, Very High-Present, High-Approaching, High-Present, Moderate, Low, and Native. The following sections describe how the species were divided into the risk evaluation priority categories.

Species Native to the Rainy-Lake of the Woods Basin, Great Lakes Basin, or the Region

The first category to be identified were those species that are native to the Rainy-Lake of the Woods Basin, because these species pose the least risk to the basin as a whole. This is not a comprehensive list of aquatic species within the Rainy-Lake of the Woods Basin. These are species identified as having been introduced into other areas of North America and, therefore, were included when downloading data from databases (U.S. Geological Survey, 2012). Although there are valid concerns about subbasin transfer, such as *Sander vitreus* (walleye) establishment in a lake previously dominated by a different predator fish species, these native transplants would be more effectively monitored on a local scale. The native species categorization resulted in 104 species.

Species Native to the Region and Great Lakes Basin, but not the Rainy-Lake of the Woods Basin

After the species native to the Rainy-Lake of the Woods Basin were categorized, the database was filtered to identify those species that were native to the Region and Great Lakes Basin, but not the Rainy-Lake of the Woods Basin. This filter resulted in 99 species, including 61 fish species. For most of these species, concern of risk to the ecosystem in the Rainy-Lake of the Woods Basin is low because they have similar climates, predators, and competition from familiar species; therefore, these species are categorized as Low priority for risk evaluation. Additionally, many of these fish have been stocked for sport fishing, are widely used in bait trade, or have expanded their range owing to stream connections including artificial locks and canals. Two species were determined to be High-Approaching priority for risk evaluation: *Trachemys scripta* (pond slider), and *Pectinatella magnifica* (magnificent bryozoan). Pond sliders are expanding their range north up the Mississippi River Basin. They are common in aquarium trade and are often illegally released by pet owners (U.S. Geological Survey, 2012). They can outcompete native turtles, and the subspecies *Trachemys scripta elegan* (red-eared slider) is one of "100 of the World's Worst Invasive Alien Species" (Invasive Species Specialist Group, 2021a). Magnificent bryozoan can develop nuisance populations that foul intake pipes and interfere with fishing nets (Ricciardi and Reiswig, 1994; Wood, 2001). They also are a host species for the salmon parasite (*Tetracapsuloides bryosalmonae*) that causes proliferative kidney disease (Okamura and Wood, 2002).

Species Native to the Great Lakes Basin, but not the Rainy-Lake of the Woods Basin or the Region

Next, the species list was filtered for those species native to the Great Lakes Basin, but not the Rainy-Lake of the Woods Basin or the Region, resulting in 14 species, including 11 fish. Most of these species are native to the Eastern Great Lakes and have been introduced via purposeful stocking or bait buckets (U.S. Geological Survey, 2012). Three of these species are currently in the Rainy-Lake of the Woods Basin: *Lepomis megalotis* (longear sunfish), *Thymallus arcticus* (Arctic grayling), and *Salmo salar* (Atlantic salmon). Arctic grayling and Atlantic salmon have been stocked in the Rainy-Lake of the Woods Basin, and the longear sunfish is speculated to be native to Minnesota (U.S. Geological Survey, 2012). All but two of the species were categorized as Low priority for risk evaluation for the Rainy-Lake of the Woods Basin. *Didymosphenia geminata* (rock snot) and *Gambusia holbrooki* (eastern mosquitofish) are categorized as High-Approaching priority for risk evaluation. Rock snot are stalked diatoms that coat stream substrates and choke out all other vegetation, eliminating food sources for many invertebrates, which in turn decreases prey for fish (Ladrera and others, 2018). Eastern mosquitofish have been shown to displace populations of native fish after introduction for mosquito control. They not only prey on mosquito larvae but also outcompete other native fish by feeding on zooplankton, fish, amphibian eggs, and invertebrates (U.S. Geological Survey, 2012).

Species Native to the Region, but not the Rainy-Lake of the Woods or Great Lakes Basins

Twenty-four species, including 12 fish species, are native to the Region, but not the Great Lakes or Rainy-Lake of the Woods Basin. None of these species are currently in Rainy-Lake of the Woods. These species were all categorized as Low priority for risk evaluation. Many have been

Figure 1. Map of the Rainy-Lake of the Woods Basin.

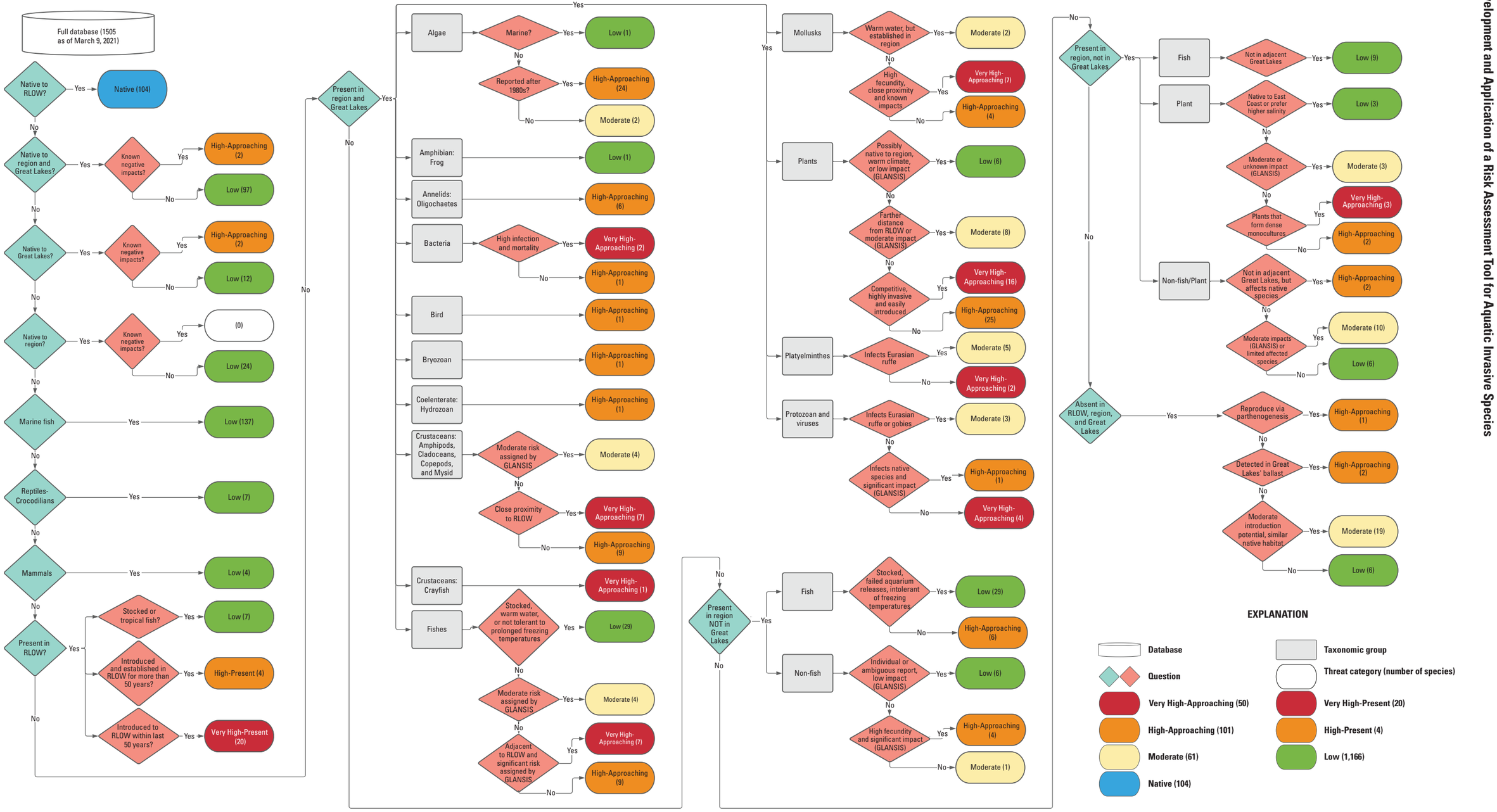

Figure 2. Decision schematic for determining priority for risk evaluation. [RLOW, Rainy Lake of the Woods; GLANSIS, Great Lakes Aquatic Nonindigenous Spcies Information System]

transported via bait bucket release, pet/aquarium release, or from range extension through connected water ways (U.S. Geological Survey, 2012). These species have natural predators and competitive species to keep any range expansion limited.

Species Not Native to the Rainy-Lake of the Woods Basin, Great Lakes Basin, or the Region

After the native species were identified and categorized, the remaining 1,265 species were systematically filtered and prioritized for detailed risk evaluation. This iterative process was meant to be a coarse screening tool to identify species that were already present, but also those that may be transported into the Rainy-Lake of the Woods Basin in the future.

Marine Fish and Crocodilians

The next step in this process was to identify those species that pose a relatively low risk of introduction to the Rainy-Lake of the Woods Basin and therefore would be in the Low priority for risk evaluation category. Species were added to this Low priority for risk evaluation category systematically based on group, proximity, and transportation or spread. The first group that was wholly categorized as Low priority were the 137 marine fish. None of these species have been found in the Rainy-Lake of the Woods Basin according to the available databases and only two were found in the Region or Great Lakes Basin—*Platichthys flesus* (European flounder) and *Lutjanus sebae* (emperor snapper). The presence of these two species was due to individual releases from aquariums or ballast, and the species have not been known to reproduce in freshwater (Cooley and others, 2000; U.S. Geological Survey, 2012). Similarly, the seven crocodilian species also were categorized as Low priority for risk evaluation. *Caiman crocodilus* (common caiman) and *Alligator mississippiensis* (American alligator) have been recorded in the Region and (or) Great Lakes Basin; however, they were the result of pet releases or escape and these species would not be able to overwinter in the Rainy-Lake of the Woods Basin (U.S. Geological Survey, 2012).

Mammals

The next group to be evaluated and categorized as Low priority for risk evaluation were non-native mammals. A total of four mammals were in this group: *Myocastor coypus* (nutria), *Hydrochoerus hydrochaeris* (capybara), *Zalophus californianus* (California sea lion), and *Otaria flavescens* (South American sea lion). The only one of these species that was present in the Rainy-Lake of the Woods Basin was the nutria. Although nutria are known to cause a great amount of damage and have high fecundity, several studies have shown nutria have not adapted to overwinter during extended periods of freezing temperatures and, therefore, would likely not survive the climate in the Rainy-Lake of the Woods Basin (Gunderson, 1955; Gosling and others, 1983; Sheffels, 2013).

Species Present in Rainy-Lake of the Woods Basin

The remaining species (1,117) were subsequently evaluated on native status, proximity, transportation or introduction ease, and any extraneous details that may alter the evaluation. The first filtering for these species focused on proximity. Species that are currently (2021) present in the Rainy-Lake of the Woods Basin were identified and totaled 31, including 9 fish and 14 plants. Six of the fish species (all in the family Salmonidae) are intentionally stocked to maintain populations and were categorized as Low priority for risk evaluation. Of the remaining three, *Piaractus brachypomus* (pirapatinga) are tropical fish that were collected after aquarium releases and unable to survive the winter climate in the Rainy-Lake of the Woods Basin (U.S. Geological Survey, 2012); this species, therefore, was designated as Low priority. *Cyprinus carpio* (common carp) and *Osmerus mordax* (rainbow smelt) were introduced into the Region during the 1800s. Because they have been part of the ecosystem in the Rainy-Lake of the Woods Basin for more than a century, they were designated as High-Present priority. Similarly, *Phalaris arundinacea* (reed canarygrass) and *Craspedacusta sowerbyi* (freshwater jellyfish) have been present in the Rainy-Lake of the Woods Basin for several decades and categorized as High-Present priority (U.S. Geological Survey, 2012). The remaining species were categorized as Very High-Present priority. These invertebrates and plants are well-known aquatic invasive species including *Butomus umbellatus* (flowering rush), *Lythrum salicaria* (purple loosestrife), *Dreissena polymorpha* (zebra mussel), and *Faxonius rusticus* (rusty crayfish). Their presence in the Rainy-Lake of the Woods Basin is having a large effect on the ecosystem, including reducing wild rice habitat and displacing native crayfish (Minnesota Department of Natural Resources, 2008, 2021).

Species Present in the Region and Great Lakes Basin, but not in Rainy-Lake of the Woods Basin

There were 190 species on the list that were present in the Region and Great Lakes Basin, but not in the Rainy-Lake of the Woods Basin. These species were evaluated by group starting with the 27 algae. One species (*Ulva* (*Enteromorpha*) *prolifera*) was categorized as Low priority for risk evaluation because it is mostly marine. Two species (*Chaetoceros muelleri* and *Chroodactylon ornatum*) have not been reported since the early 1980s and were, therefore, categorized at Moderate priority. The remaining algae were categorized as High-Approaching priority. These species may eventually elevate to

Very High priority if their spread accelerates, but most of the species were introduced via ballast and do not currently appear to be spreading quickly (U.S. Geological Survey, 2012).

One amphibian-frog, *Xenopus laevis* (African Clawed Frog), was on the list. This species may have been originally released from laboratories because they are used frequently in laboratory testing (U.S. Geological Survey, 2012). Occurrences in the Region have been limited to individual collections, so the species was categorized as Low priority for risk evaluation.

Six Annelids-Oligochaetes were on the list, and all were categorized as High-Approaching priority for risk evaluation. Four of these species are in Lake Superior or other basins near the Rainy-Lake of the Woods Basin, and NAS indicates two of these species (*Gianius aquaedulci*, *Potamothrix vejdovskyi*) have become the dominant benthic invertebrate species in nearshore areas (U.S. Geological Survey, 2012). Owing to their small size, they may be easily transported unknowingly via wildlife or human activities, which was a determining factor in their categorization.

Three bacteria species are present in the Region and Great Lakes Basin. Based on current risk assessments, *Aeromonas salmonicida* does not pose a significant environmental risk in the Great Lakes Basin (National Oceanic and Atmospheric Administration, 2019). However, these bacteria affect native and introduced salmon species (National Oceanic and Atmospheric Administration, 2019); therefore, *Aeromonas salmonicida* was categorized as High-Approaching priority for risk evaluation. Both *Renibacterium* (*Corynebacterium*) *salmoninarum* (bacterial kidney disease) and *Piscirickettsia* cf. *salmonis* (muskie pox) can have high infection rates and cause mortality in desirable native fish populations (National Oceanic and Atmospheric Administration, 2019). Bacterial kidney disease is present in adjacent basins and fish culture facilities, which may increase the rate of introduction.

The only bird species currently (2021) on the list for aquatic invasive species present in the Region and Great Lakes Basin, but not the Rainy-Lake of the Woods Basin, is *Cygnus olor* (mute swan). The mute swan was categorized as Very High-Approaching priority for risk evaluation for several reasons, including its presence in adjacent watersheds, its aggressive nature towards other waterfowl and humans, and its ferocious appetite, which causes uprooting of many aquatic plants including wild rice (U.S. Fish and Wildlife Service, 2019; U.S. Geological Survey, 2019).

The freshwater bryozoan *Lophopodella carteri* is native to Asia and is thought to have arrived attached to landscaping and greenhouse plants (U.S. Geological Survey, 2012). These bryozoans are able to survive the digestive tract of migratory waterfowl, which may provide a pathway into the Rainy-Lake of the Woods Basin (Bushnell, 1965). Because they can create nuisance encrusting colonies (Ricciardi and Reiswig, 1994), but are not yet present in adjacent watersheds, they are categorized as High-Approaching priority for risk evaluation.

The only nonindigenous Coelenterate-Hydrozoan in the Region and Great Lakes Basin but not in the Rainy-Lake of the Woods Basin is *Cordylophora caspia*. This species is present in the St. Louis River Basin and likely was introduced from ballast or in aquarium release. Owing to their competition with larva fish for zooplanktonic prey, they have been categorized as Very High-Approaching priority for risk evaluation.

The 20 species in the crustacean groups of amphipods, cladocerans, copepods, and mysid were evaluated together. Many of these species originally were introduced via ballast and are being spread with the assistance of recreational boats and other invasive species (U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019). These 20 species, their priority categories, and some simplified comments as to reasoning for the categorization are shown in table 1. These comments are based on information for each species within the databases. Those designated as Moderate priority for risk evaluation are not known to pose significant negative impact based on GLANSIS Risk Assessments (National Oceanic and Atmospheric Administration, 2019). Those in the High-Approaching and Very High-Approaching priority for risk evaluation categories all can pose negative impacts and have been categorized in these two categories mainly owing to the proximity to the Rainy-Lake of the Woods Basin.

Red swamp crayfish (*Procambarus clarkii*) are native to the Gulf of Mexico Region of the United States and are the only crayfish in the database that is present in the Region and Great Lakes Basin but not in the Rainy-Lake of the Woods Basin. They have been sold in aquaculture and aquarium trade, which has caused their introduction throughout the United States (U.S. Geological Survey, 2012). Red swamp crayfish are generalist feeders that compete with native crayfish, other invertebrates, and fish. Their burrows can destabilize banks, causing erosion and damage to vegetation including rice fields (U.S. Geological Survey, 2012). Because of the numerous possible impacts, red swamp crayfish are designated as Very High-Approaching priority for risk evaluation.

Forty-six fish species are on the list that are not yet present in the Rainy-Lake of the Woods Basin but are present in the Region and Great Lakes Basin. Many of those categorized as Low priority for risk evaluation are stocked sport fish or forage fish, failed warm-water aquarium releases, or cannot survive in the Rainy-Lake of the Woods Basin's subfreezing climate (U.S. Geological Survey, 2012). The four species designated as Moderate priority for risk evaluation do not pose an immediate risk to the Rainy-Lake of the Woods Basin but have the potential to affect native food webs if introduced. Seven species were designated as High-Approaching priority. Four of these species are in the Duluth, Minnesota, area or Lake Superior; however, their mode of spread historically has been through stream connectivity and release or escape (U.S. Geological Survey, 2012). Therefore, if precautions are taken to educate the public that these species can alter native ecosystems and to help identify the spread, the spread

Table 1. Crustacean species not native to the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region or Great Lakes Basin, with the priority for risk evaluation with comments and reasoning for the category.

[Information summarized from U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019]

Group	Scientific name	Common name	Priority for risk evaluation	Comment
Crustaceans-Copepods	*Nitokra incerta*	a harpacticoid copepod	Moderate	Currently in Lake Michigan, but not recorded since 2000
Crustaceans-Copepods	*Thermocyclops crassus*	a copepod	Moderate	Currently in Lake Michigan and Superior, no known negative impact
Crustaceans-Copepods	*Cyclops strenuus*	a copepod	Moderate	May be relic populations, no known negative impact
Crustaceans-Copepods	*Heteropsyllus* nr. *nunni*	a copepod	Moderate	Currently in Lakes Michigan and Huron, like deep water greater than 15 meters
Crustaceans-Cladocerans	*Eubosmina maritima*	a cladoceran	High-Approaching	Currently in State of Michigan
Crustaceans-Copepods	*Megacyclops viridis*	a cyclopoid copepod	High-Approaching	Found in high density in ruffe digestive tracks
Crustaceans-Copepods	*Argulus japonicus*	Japanese fishlouse	High-Approaching	Channel catfish, carp, trout, and many others are host species
Crustaceans-Copepods	*Eurytemora affinis*	a calanoid copepod	High-Approaching	Currently in Lake Superior, very adaptable
Crustaceans-Copepods	*Eurytemora affinis*	a calanoid copepod	High-Approaching	Currently in Lakes Michigan and Superior, high fecundity
Crustaceans-Copepods	*Nitokra hibernica*	a harpacticoid copepod	High-Approaching	Currently in Lake Superior
Crustaceans-Copepods	*Salmincola lotae*	a parasitic copepod	High-Approaching	Currently in Lake Superior, only infect *Lota lota* (Burbot)
Crustaceans-Copepods	*Schizopera borutzkyi*	an oarsman	High-Approaching	Currently in Lake Superior, like deep water
Crustaceans-Copepods	*Heteropsyllus nunni*	a copepod	High-Approaching	Currently in Lake Superior, lacking additional information
Crustaceans-Amphipod	*Echinogammarus ischnus*	a scud	Very High-Approaching	Currently in St. Louis County, Minnesota, most abundant non-daphnia zooplankton
Crustaceans-Amphipod	*Gammarus tigrinus*	tiger scud	Very High-Approaching	Currently in St. Louis County, Minn., displaces other invasives
Crustaceans-Cladocerans	*Diaphanosoma fluviatile*	a cladoceran	Very High-Approaching	Currently in northern Wisconsin, spread via fishing boats
Crustaceans-Cladocerans	*Daphnia lumholtzi*	a waterflea	Very High-Approaching	Currently in St. Louis County, Minn., completes with native daphnia, spread via fishing boats
Crustaceans-Cladocerans	*Cercopagis pengoi*	fishhook waterflea	Very High-Approaching	Non-edible, compete with other planktivores
Crustaceans-Copepods	*Neoergasilus japonicus*	a parasitic copepod	Very High-Approaching	Currently in Lake Huron, spreads rapidly in host fish from many different families
Crustaceans-Mysids	*Hemimysis anomala*	bloody red shrimp	Very High-Approaching	Currently in Lakes Michigan and Superior, causes dramatic changes in food webs where introduced

of these species could be minimized (Anderson and others, 2008). The six species in the Very-High Approaching priority for risk evaluation category also are in watersheds adjacent to the Rainy-Lake of the Woods Basin (U.S. Geological Survey, 2012). These six species have had significant negative impact in aquatic systems where they have been introduced, including displacing native species, destroying habitat, and feeding on native fish eggs and larva. All six species are highly fecund species and are adaptable to the climate in the Rainy-Lake of the Woods Basin (U.S. Geological Survey, 2012). The 46 species not yet present in the Rainy-Lake of the Woods Basin but present in the Region and Great Lakes Basin, and comments as to the justification for their categorization, are shown in table 2. These comments are based on information for each species within the databases.

Thirteen mollusks are in the bivalve and gastropod groups summarized in table 3. The two species categorized as Moderate priority for risk evaluation prefer warmer waters than provided by the Rainy-Lake of the Woods Basin (U.S. Geological Survey, 2012); however, climate change may cause increased temperature in the Rainy-Lake of the Woods Basin, which would allow for warmer-water species to become established. The remaining species were categorized as High-Approaching or Very High-Approaching based on their proximity, fecundity, reproductive process, and impacts on ecosystems where they have been introduced.

The 55 plant species present in the Region and Great Lakes Basin, but not the Rainy-Lake of the Woods Basin, vary in their modes of spread and introduction as well as their priority categorization. The species, priority for risk evaluation, and comments as to proximity and reasoning for the categorization are shown in table 4. Six species are designated as Low priority for risk evaluation owing to proximity, climate preference, or questions regarding their native status. Similarly, eight species were designated as Moderate priority for risk evaluation owing to their moderate impact in other introduced areas or their distance from the Rainy-Lake of the Woods Basin. For example, *Myosotis scorpioides* (forget-me-not) is in proximity to the Rainy-Lake of the Woods Basin but has become naturalized and has had moderate impact on locations where it was introduced. The 24 High-Approaching priority for risk evaluation species could become Very High without oversight of their possible vectors. Lastly, the 16 Very High-Approaching priority for risk evaluation species are either directly adjacent to the Rainy-Lake of the Woods Basin or have successful reproduction and spread via multiple pathways. These 15 species have very invasive tendencies and can outcompete established native and non-native species.

The flat worms group, *Platyhelminthes*, has seven species in the Region and Great Lakes Basin. Five of these species primarily infect the exotic Eurasian ruffe and were categorized as Moderate priority for risk evaluation; however, they may be elevated to a higher priority for risk evaluation if the ruffe is introduced into the Rainy-Lake of the Woods Basin. *Leyogonimus polyoon* is the parasite that was responsible for mass avian mortalities in Lake Winnibigoshish, Minn., in 2007 and 2008 (U.S. Geological Survey, 2012). Because of its proximity and possible impact, it was designated as Very High-Approaching priority for risk evaluation. *Ichthyocotylurus pileatus* has been found in the St. Louis River headwaters and causes mortality in desirable native fish including *Perca flavescens* (yellow perch), *Sander vitreus* (walleye), and *Percopsis omiscomaycus* (trout-perch), as well as come cyprinid species (U.S. Geological Survey, 2012).

The last two groups present in the Region and Great Lakes Basin, but not the Rainy-Lake of the Woods Basin, are protozoans and viruses. All of these species are relatively close to the Rainy-Lake of the Woods Basin and can be transported via multiple pathways (National Oceanic and Atmospheric Administration, 2019). The four species that are ranked as Very High-Approaching have proven to have significant impacts, and in some cases high mortality, on the species they infect including *P. flavescens*, *Micropterus salmoides* (largemouth bass), and salmonoid species (table 5).

Species Present in the Region but not in the Great Lakes or Rainy-Lake of the Woods Basin

Currently 46 recorded non-native species are present in the Region but are not present in the Great Lakes or Rainy-Lake of the Woods Basins, with fish (35) accounting for most of the species. This filter was divided into fish species and non-fish species. The non-fish species, their assessment priority, and comments regarding justification for those categorizations are shown in table 6. Of the fish species, 28 were categorized as Low priority for risk evaluation and mostly consist of failed aquarium releases, stocked fish, or those that do not tolerate extended near-freezing temperatures (table 7). Six species of invasive carp are present in the Region; owing to the invasive nature of these species, they were all designated as High-Approaching. Three of these carp are the same species, *Mylopharyngodon piceus* (black carp), but are diploid, triploid, or undesignated reproductive status.

Species Present in the Great Lakes Basin but not in the Region or Rainy-Lake of the Woods Basin

Forty invasive species have been determined to be present in the Great Lakes Basin but not the Rainy-Lake of the Woods Basin or the Region; nine were fish and 13 were plants. Of the 18 nonfish and nonplant species, two were designated at High-Approaching because they have been found in other assessments to have ecological impacts to native communities (U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019) (table 8). The three

Table 2. Fish species not native to the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region or Great Lake Basins, with the current priority for risk evaluation with comments and reasoning for the category.

[Information summarized from U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019]

Scientific name	Common name	Priority for risk evaluation	Comment
Alosa sapidissima	American shad	Low	Stocked populations failed
Ameiurus catus	white catfish	Low	Stocked
Carassius carassius	crucian carp	Low	Only specimen in Region from Chicago, Illinois, collected in 1910
Chitala ornata	clown knifefish	Low	Warm-water fish, failed aquarium releases
Colossoma or Piaractus sp.	unidentified pacu	Low	Warm-water fish, failed aquarium releases
Coregonus maraena	Maraena whitefish	Low	Stocked populations failed
Cyprinella whipplei	steelcolor shiner	Low	Does not survive below −0.5° Celsius
Dorosoma petenense	threadfin shad	Low	Does not survive below 7° Celsius
Lepomis microlophus	redear sunfish	Low	Stocked
Menidia beryllina	inland silverside	Low	Only specimen in Region from Minneapolis and St. Paul, Minnesota, collected in 1950
Micropterus punctulatus	spotted bass	Low	Stocked
Morone chrysops x *Morone saxatilis*	wiper	Low	Stocked
Morone saxatilis	striped bass	Low	Stocked populations failed
Noturus insignis	margined madtom	Low	Closest population is in isolated lake in Michigan
Oncorhynchus mykiss whitei	Little Kern golden trout	Low	Stocked populations failed
Oncorhynchus clarkii	cutthroat trout	Low	Stocked
Oncorhynchus gorbuscha	pink salmon	Low	Stocked
Oncorhynchus kisutch	coho salmon	Low	Stocked
Oncorhynchus tshawytscha	chinook salmon	Low	Stocked
Oreochromis, Sarotherodon, Tilapia sp.	tilapia	Low	Warm-water fish
Osteoglossum bicirrhosum	silver arowana, arowana, arawana, aruana, bandfish, silver aruana	Low	Warm-water fish, failed aquarium releases
Phractocephalus hemioliopterus	redtail catfish	Low	Warm-water fish, failed aquarium releases
Poecilia reticulata	guppy	Low	Warm-water fish, failed aquarium releases
Prosopium williamsoni	mountain whitefish	Low	Stocked population in Michigan extirpated
Pygocentrus nattereri	red piranha	Low	Warm-water fish, failed aquarium releases
Salmo trutta x *Salvelinus fontinalis*	tiger trout	Low	Stocked
Tilapia buttikoferi	zebra tilapia	Low	Warm-water fish
Tilapia sp.	unidentified tilapia	Low	Unspecified tilapia collected near Chicago, Ill.
Tinca tinca	tench	Low	Not found in Region since late 1800s
Carassius auratus x *Cyprinus carpio*	goldfish x common carp	Moderate	Exotic hybrid, goldfish is High-Approaching, carp is High-Present
Channa argus	northern snakehead	Moderate	Does not survive below 0 °Celsius
Cyprinus rubrofuscus	koi	Moderate	Aquarium releases
Scardinius erythrophthalmus	rudd	Moderate	Bait bucket releases in neighboring States

Table 2. Fish species not native to the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region or Great Lake Basins, with the current priority for risk evaluation with comments and reasoning for the category.—Continued

[Information summarized from U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019]

Scientific name	Common name	Priority for risk evaluation	Comment
Alosa pseudoharengus	alewife	High-Approaching	In Duluth, Minn., modifies food web
Apeltes quadracus	fourspine stickle-back	High-Approaching	Introduction via ballast, established in Thunder Bay, Ontario
Carassius auratus	goldfish	High-Approaching	In Duluth, Minn., but does not typically have high fecundity to become nuisance
Ctenopharyngodon idella var. *triploid*	grass carp (triploid)	High-Approaching	In La Crosse-Pine watershed, Wisconsin; nonreproductive but stock maybe contaminated
Hypophthalmichthys nobilis	bighead carp	High-Approaching	In Duluth, Minn., prefers large-river habitats
Misgurnus anguillicaudatus	oriental weatherfish	High-Approaching	In Chicago, Ill., area, out competes for food and increases turbidity
Petromyzon marinus	sea lamprey	High-Approaching	In Duluth, Minn., unknown if spawning habitat in the Rainy-Lake of the Woods Basin would be sufficient
Ctenopharyngodon idella	grass carp	Very High-Approaching	In St. Cloud, Minn., high fecundity
Ctenopharyngodon idella var. *diploid*	grass carp (diploid)	Very High-Approaching	Reproductive variant
Gymnocephalus cernua (*cenuus*)	ruffe	Very High-Approaching	In Duluth, Minn., outcompetes native species for food
Morone americana	white perch	Very High-Approaching	In Duluth, Minn., feeds heavily on native fish eggs
Neogobius melanostomus	round goby	Very High-Approaching	In Duluth, Minn., rapidly displaces native species
Proterorhinus semilunaris	freshwater tubenose goby	Very High-Approaching	In Duluth, Minn., and Thunder Bay, Ontario, competes with native darters

Table 3. Mollusk species not native to the Region (approximately 800-kilometer radius from Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region or Great Lakes Basin, with the current priority for risk evaluation with comments and reasoning for the category.

[Information summarized from U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019]

Scientific name	Common name	Priority for risk evaluation	Comment
Radix auricularia	European ear snail, big-eared radix	Moderate	In Chicago, Illinois, but prefers warm water (about 19 °Celsius)
Eupera cubensis	mottled fingernail clam	Moderate	In Chicago, Ill., native to Central and Southern United States
Pisidium amnicum	greater European peaclam	High-Approaching	In Duluth, Minnesota, and Thunder Bay, Ontario, hermaphrodites but low fecundity
Pisidium henslowanum	Henslow peaclam	High-Approaching	In Duluth, Minn., hermaphrodite, high fecundity, requires calcium-rich waters
Pisidium moitessierianum	pygmy peaclam	High-Approaching	In Duluth, Minn., hermaphrodites but moderate fecundity, may not tolerate subfreezing temperatures
Pisidium supinum	humpbacked peaclam	High-Approaching	In Duluth, Minn., hermaphrodites but low fecundity
Cipangopaludina japonica	Japanese mysterysnail	Very High-Approaching	In St. Croix River Headwaters, Wisconsin, high fecundity
Corbicula fluminea	Asian clam	Very High-Approaching	In Duluth, Minn., hermaphrodite, high fecundity, biofouler
Dreissena bugensis	quagga mussel	Very High-Approaching	In Duluth, Minn., very high fecundity, appears to be displacing zebra mussels
Dreissena sp.	a dreissenid mussel	Very High-Approaching	Undifferentiated dreissenid mussel
Potamopyrgus antipodarum	New Zealand mud snail	Very High-Approaching	In Duluth, Minn., and Thunder Bay, Ontario, ovoviviparous and parthenogenic, very high fecundity, can survive digestive tracts of predators
Sphaerium corneum	European fingernail clam	Very High-Approaching	In Thunder Bay, Ontario, high fecundity
Valvata piscinalis	European stream valvata	Very High-Approaching	In Duluth, Minn., and Thunder Bay, Ontario, high fecundity

Table 4. Plant species not native to the Rainy-Lake of the Woods Basin, the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region or Great Lakes Basin, with the current priority for risk evaluation with comments and reasoning for the category.

[Information summarized from multiple data sources (U.S. Geological Survey, 2012; University of Georgia - Center for Invasive Species and Ecosystem Health and National Park Service, 2018; National Oceanic and Atmospheric Administration, 2019; Michigan State University Department of Entomology Laboratory for Applied Spatial Ecology and Technical Services, 2020; U.S. Department of Agriculture - Natural Resources Conservation Service, 2020; Centre of Agriculture and Biosciences International, 2021; Invasive Species Specialist Group, 2021b). USDA, U.S. Department of Agriculture; NRCS, Natural Resources Conservation Service]

Scientific name	Common name	Priority for risk evaluation	Comment
Typha domingensis	southern cattail	Low	Mostly found in warmer climates
Agrostis gigantea	redtop	Low	In St. Louis and Cook Counties, Minnesota, cultivated for forage, low impact across the United States
Landoltia punctata	dotted duckweed	Low	Does not tolerate freezing, absolute minimum −20 ° Celsius air temperature
Lupinus polyphyllus	marsh lupine	Low	In St. Louis County, Minn., USDA NRCS lists it as native to the Rainy-Lake of the Woods Basin
Pistia stratiotes	water lettuce	Low	Plants do not tolerate freezing temperatures
Veronica anagallis-aquatica	water speedwell	Low	In South Dakota, USDA NRCS lists it as native to the Rainy-Lake of the Woods Basin
Juncus gerardii	saltmarsh rush	Moderate	In Kittson County, Minn., naturalized in Great Lakes Basin with moderate impact
Alopecurus geniculatus var. *geniculatus*	water foxtail	Moderate	In Lake Michigan drainage, overall low production
Hydrilla verticillata	hydrilla	Moderate	In Menomine, Wisconsin, occurrences were eradicated
Myosotis scorpioides	forget-me-not	Moderate	In St. Louis and Cook Counties, Minn., widespread and naturalized with moderate impacts
Myosoton aquaticum	giant chickweed	Moderate	In Duluth, Minn., not generally aggressive
Nasturtium sp.	a watercress	Moderate	In Winneshiekm, Iowa, unidentified watercress
Pontederia crassipes (*Eichhornia crassipes*)	water hyacinth	Moderate	In Minneapolis and St. Paul, Minn., can dominate aquatic systems, but does tolerate long-term freezing, records in the area indicate it failed or was eradicated
Puccinellia distans	weeping alkaligrass	Moderate	In Lake Michigan drainage, low competitive ability
Alnus glutinosa	black alder	High-Approaching	In Lake Michigan drainage, pioneer species that can fix soil nitrogen and shade competitor plants
Arundo donax	giant reed	High-Approaching	In Dodge County, Nebraska, invasive where introduced, forms dense thickets
Cabomba caroliniana	Carolina fanwort	High-Approaching	In Michigan State, aquarium releases and vegetative reproduction help the spread
Chenopodium glaucum	oakleaf goosefoot	High-Approaching	In St. Louis County, Minn., high fecundity, but not often noxious
Echinochloa crus-galli	barnyardgrass	High-Approaching	In St. Louis County, Minn., may produce allelochemicals, easily succession that may not persist over time
Epilobium hirsutum	hairy willow herb	High-Approaching	In Lake Michigan drainage, shown to have moderate impact in Great Lakes Basin
Hydrilla verticillata [monoecious]	monoecious hydrilla	High-Approaching	In Menomonie, Wis., highly invasive and easily transported via recreational boats

Table 4. Plant species not native to the Rainy-Lake of the Woods Basin, the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region or Great Lakes Basin, with the current priority for risk evaluation with comments and reasoning for the category.—Continued

[Information summarized from multiple data sources (U.S. Geological Survey, 2012; University of Georgia - Center for Invasive Species and Ecosystem Health and National Park Service, 2018; National Oceanic and Atmospheric Administration, 2019; Michigan State University Department of Entomology Laboratory for Applied Spatial Ecology and Technical Services, 2020; U.S. Department of Agriculture - Natural Resources Conservation Service, 2020; Centre of Agriculture and Biosciences International, 2021; Invasive Species Specialist Group, 2021b). USDA, U.S. Department of Agriculture; NRCS, Natural Resources Conservation Service]

Scientific name	Common name	Priority for risk evaluation	Comment
Hydrocotyle ranunculoides	floating marsh pennywort	High-Approaching	In Minneapolis and St. Paul, Minn., can become invasive where introduced
Juncus inflexus	European meadow rush	High-Approaching	In Lake Superior, may out compete native species
Lycopus europaeus	gypsywort	High-Approaching	In Upper Fox River, Wis., invasive where introduced, remain viable through digestion
Mentha aquatica	water mint	High-Approaching	In Lake Superior, mint species are generally invasive where introduced
Mentha spicata	spearmint	High-Approaching	In Houghton County, Mich., mint species are generally invasive where introduced
Najas minor	brittle waternymph	High-Approaching	In Minneapolis and St. Paul, Minn., can form dense monocultures
Nasturtium microphyllum	onerow yellowcress	High-Approaching	In St. Louis County, Minn., high risk of monoculture
Oenanthe javanica	java waterdropwort	High-Approaching	In Le Sueur County, Minn., invasive tendencies
Persicaria maculosa	spotted ladysthumb	High-Approaching	In St. Louis County, Minn., secondary noxious weed in Minn.
Poa trivialis	rough bluegrass	High-Approaching	In St. Louis County, Minn., planted for forage, naturalized
Sagittaria sagittifolia	Hawaii arrowhead	High-Approaching	In Washington County, Minn., nuisance species in more than 50 countries
Salix alba	golden willow	High-Approaching	In St. Louis County, Minn., may hybridize with native willow
Salix fragilis	crack willow	High-Approaching	In St. Louis County, Minn., can form dense thickets and hybridize with native willow
Salix purpurea	purple osier	High-Approaching	In Duluth, Minn., can form dense stands and hybridize with native willow
Solanum dulcamara	bitter nightshade	High-Approaching	In St. Louis County, Minn., poisonous, can inhibit native plants as a clinging vine
Tamarix spp.	saltcedar	High-Approaching	In Fargo, North Dakota, high fecundity, rapid growth, outcompete native species
Veronica beccabunga	European speedwell	High-Approaching	In Lake Superior near Keweenaw Peninsula, Mich., potentially invasive, but limited competition with native species where introduced
Cirsium palustre	marsh thistle	Very High-Approaching	In Baptism-Brule watershed, Minn., considered noxious weed
Conium maculatum	poison-hemlock	Very High-Approaching	In Kittson County, Minn., highly toxic, highly competitive
Egeria densa	Brazilian waterweed	Very High-Approaching	In Minneapolis and St. Paul, Minn., easily transported via recreational boats
Frangula alnus	glossy buckthorn	Very High-Approaching	In Duluth, Minn., high fecundity, shades out native plants

Table 4. Plant species not native to the Rainy-Lake of the Woods Basin, the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region or Great Lakes Basin, with the current priority for risk evaluation with comments and reasoning for the category.—Continued

[Information summarized from multiple data sources (U.S. Geological Survey, 2012; University of Georgia - Center for Invasive Species and Ecosystem Health and National Park Service, 2018; National Oceanic and Atmospheric Administration, 2019; Michigan State University Department of Entomology Laboratory for Applied Spatial Ecology and Technical Services, 2020; U.S. Department of Agriculture - Natural Resources Conservation Service, 2020; Centre of Agriculture and Biosciences International, 2021; Invasive Species Specialist Group, 2021b). USDA, U.S. Department of Agriculture; NRCS, Natural Resources Conservation Service]

Scientific name	Common name	Priority for risk evaluation	Comment
Glyceria maxima	reed mannagrass	Very High-Approaching	In Minneapolis and St. Paul, Minn., forms dense stands spread by seed and rhizomes
Impatiens glandulifera	ornamental jewel-weed	Very High-Approaching	In Thunder Bay, Ontario, "considered to be one of the most invasive plants of the world."
Juncus compressus	roundfruit rush	Very High-Approaching	In Kittson County, Minn., invasive where established, outcompete native species
Lysimachia nummularia	creeping jenny	Very High-Approaching	In Cass County, Minn., spreads rapidly and can create dense mats
Lysimachia punctata	large yellow loose-strife	Very High-Approaching	In northern Wis. and Upper Peninsula of Mich., forms dense stands, outcompetes natives
Lysimachia vulgaris	garden loosestrife	Very High-Approaching	In St. Louis County, Minn., spreads via rhizomes, outcompetes natives and invasive purple loosestrife
Mentha X *gracilis*	gingermint	Very High-Approaching	In Douglas County, Wis., noxious weed hybrid
Myriophyllum aquaticum	parrot feather	Very High-Approaching	In Buffalo-Whitewater Basin, Minn. and Wis., very successful vegetative reproduction including rhizomes, may not survive extended severe freezing
Nasturtium officinale	watercress	Very High-Approaching	In the Roseau River, Minn., noxious weed or invasive
Nitellopsis obtusa	starry stonewort	Very High-Approaching	In Upper Red Lake and Chippewa National Forest, Minn., "highly aggressive competitor," displace other non-native species
Nymphoides peltata	yellow floating-heart	Very High-Approaching	In Lower Wisconsin River Basin, creates "monotypic dense patches."
Rorippa sylvestris	creeping yellow-cress (keek)	Very High-Approaching	In St. Louis County, Minn., allelopathic, noxious weed

Table 5. Protozoan and virus species not native to the Region (approximately 800-kilometer radius from Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region or Great Lakes Basin, with the current priority for risk evaluation with comments and reasoning for the category.

[Information summarized from U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019]

Group	Scientific name	Common name	Priority for risk evaluation	Comment
Protozoans	*Trypanosoma acerinae*	a flagellate parasite	Moderate	In St. Louis County, Minnesota, infects ruffe
Protozoans	*Sphaeromyxa sevastopoli*	a myxosporean parasite	Moderate	In St. Louis County, Minn., infects round and tubenose gobies
Protozoans	*Psammonobiotus communis*	a testate amoeba	Moderate	In eastern Lake Superior, Ontario, relatively underinvestigated
Viruses	*Rhabdovirus carpio*	spring viremia of carp (SVC)	High-Approaching	In Minnehaha Creek, Minn., infects carp but may infect native and non-native fish
Protozoans	*Myxobolus cerebralis*	salmonid whirling disease	Very High-Approaching	In Duluth, Minn., affects native and stocked salmonoids, perpetuated from hatcheries
Protozoans	*Heterosporis sutherlandae*	a microsporidian parasite	Very High-Approaching	In Vilas County, Wisconsin, infects native yellow perch in Great Lakes Basin, but may infect other native and non-native species
Viruses	*Ranavirus*	largemouth bass virus (LMBV)	Very High-Approaching	In Wolf River, Wis., infects largemouth bass
Viruses	*Novirhabdovirus* sp. genotype IV sublineage b	viral hemorrhagic septicemia virus (VHSV-IVb)	Very High-Approaching	In Duluth, Minn., and Lake Superior, non-specific infection, high mortality

Table 6. Non-fish species not native to the Rainy-Lake of the Woods Basin, the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region, with the current priority for risk evaluation with comments and reasoning for the category.

[Information summarized from U.S. Geological Survey, 2012; Fofonoff and others, 2018; National Oceanic and Atmospheric Administration, 2019]

Scientific name	Common name	Priority for risk evaluation	Comment
Ambystoma macrodactylum	Long-toed Salamander	Low	Single occurrence in Iowa
Brachionus forficula	a brachionid rotifer	Low	In Dickey County, North Dakota, little information to gauge invasiveness
Caiman crocodilus	common caiman	Low	Failed pet release in Minneapolis and St. Paul, Minnesota.
Elaphoidella bidens bidens	a copepod	Low	Nonspecific occurrence in publication indicating reports in Minn.
Lernaea cyprinacea	anchor worm	Low	Nonspecific occurrence in publication indicating reports in Wisconsin
Urnatella gracilis	freshwater goblet worm	Low	Nonindigenous occurrence Bremer County Iowa, no impacts reported
Marsilea mutica	Australian water-clover	Moderate	In Boone County, Missouri, readily sold for aquariums
Alisma plantago-aquatica	European water plantain	High-Approaching	In Winnipeg, Manitoba, aggressive self-sower, like American water-plantain
Corbicula largillierti	a freshwater clam	High-Approaching	In Davenport, Iowa, understudied variant but other species of *Corbicula*, high fecundity and invasive
Corbicula sp. Form D	a freshwater clam	High-Approaching	Undifferentiated *Corbicula* but other species of *Corbicula*, high fecundity and invasive
Trachemys scripta elegans	Red-eared Slider	High-Approaching	In Minneapolis and St. Paul, Minn., appears to be a reproducing population, can be invasive where introduced

Table 7. Fish species not native to the Rainy-Lake of the Woods Basin, the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region, with the current priority for risk evaluation with comments and reasoning for the category.

[Information summarized from U.S. Geological Survey, 2012; Fofonoff and others, 2018; National Oceanic and Atmospheric Administration, 2019]

Scientific name	Common name	Priority for risk evaluation	Comment
Amphilophus citrinellus	Midas Cichlid	Low	Failed aquarium release in Silver Lake, North St. Paul, Minnesota
Archoplites interruptus	Sacramento Perch	Low	Failed stocking in North Dakota
Astronotus ocellatus	Oscar	Low	Failed aquarium release in Snake River, Minn.
Balantiocheilos melanopterus	tricolor sharkminnow	Low	Failed aquarium release in Indiana
Barbonymus schwanenfeldii	tinfoil barb	Low	Failed aquarium release in Indiana
Channa micropeltes	Giant Snakehead	Low	Failed aquarium release in Wisconsin
Fundulus catenatus	Northern Studfish	Low	Not reported in Region since 1974
Herichthys cyanoguttatus (*Cichlasoma cyanoguttatum*)	Rio Grande Cichlid	Low	Aquarium release in Illinois and Nebraska, does not seem to tolerate temperatures below 14.2 °Celsius
Heros severus	Banded Cichlid	Low	Failed aquarium release in Nebraska
Iotichthys phlegethontis	Least Chub	Low	In LaMoure County, N. Dak., escaped aquaculture facility, unknown impacts
Lepomis auritus	Redbreast Sunfish	Low	Stocked for sport in South Dakota.
Melanotaenia nigrans	black-banded rainbowfish, Australian red-tailed rainbowfish	Low	Failed escape confinement in Illinois
Morone americana x *Morone mississippiensis*	white perch x yellow bass	Low	In Lower Illinois River, Ill., hybridization with native species
Morone chrysops x *M. mississippiensis*	white bass x yellow bass	Low	Hybrid not found in Region since 1975
Oncorhynchus clarkii henshawi	Lahontan cutthroat trout	Low	Failed stocking in Minnesota
Oncorhynchus clarkii lewisi	Westslope Cutthroat Trout	Low	Failed stocking in Minnesota
Oncorhynchus mykiss irideus	coastal rainbow trout	Low	Stocked in Indiana
Oncorhynchus mykiss kamloops strain	Kamloops trout	Low	Stocked in Minnesota
Oreochromis mossambicus	Mozambique tilapia	Low	Reported in Ill., does not tolerate temperatures below 10.2 °Celsius
Oreochromis niloticus	Nile tilapia	Low	Collected in Minneapolis and St. Paul, Minn., does not typically tolerate temperatures below 8° Celsius
Oreochromis sp.	tilapia	Low	Collected in Minneapolis and St. Paul, Minn., does not typically tolerate temperatures below 8 °Celsius
Pangasianodon hypophthalmus	iridescent shark	Low	Failed aquarium release in Illinois
Pseudoplatystoma fasciatum	tiger catfish	Low	Failed aquarium release in Illinois
Pterygoplichthys sp.	sailfin armored catfish	Low	Failed aquarium release in Wisconsin
Pygocentrus or Serrasalmus sp.	unidentified piranha	Low	Failed aquarium release in Iowa
Sander lucioperca	Zander	Low	Stocked in N. Dak.

Table 7. Fish species not native to the Rainy-Lake of the Woods Basin, the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Region, with the current priority for risk evaluation with comments and reasoning for the category.—Continued

[Information summarized from U.S. Geological Survey, 2012; Fofonoff and others, 2018; National Oceanic and Atmospheric Administration, 2019]

Scientific name	Common name	Priority for risk t evaluation	Comment
Sorubim sp.	unidentified shovel-nose catfish	Low	Failed aquarium release in Minnesota
Synodontis ocellifer	Ocellated Synodontis	Low	Failed aquarium release in Minnesota, does not typically tolerate temperatures below 20 °Celsius
Hypophthalmichthys molitrix	silver carp	High-Approaching	In Mississippi River near Minneapolis and St. Paul, Minn., negative impacts on native foodwebs where introduced
Hypophthalmichthys molitrix x *Hypophthalmichthys nobilis*	hybrid silver/bighead carp	High-Approaching	In Mississippi River near La Crosse, Wis., hybrid of exotic species
Mylopharyngodon piceus	black carp (diploid)	High-Approaching	In Mississippi River near Pike County, Ill., negative impacts on native foodwebs where introduced
Mylopharyngodon piceus var. *triploid*	black carp (triploid)	High-Approaching	In Mississippi River and Illinois River near St. Louis, Missouri
Mylopharyngodon piceus	black carp	High-Approaching	Nonspecific reproductive status
Hypophthalmichthys sp.	bigheaded carps	High-Approaching	Nonspecific species, in Iowa and Illinois

Table 8. Species not native to the Rainy-Lake of the Woods Basin, the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Great Lakes Basin, with the current priority for risk evaluation with comments and reasoning for the category.

[Information summarized from U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019; Agriculture Victoria, 2020; United Nations Educational, Scientific, and Cultural Organization, 2021]

Group	Scientific Name	Common Name	Priority for risk evaluation	Comment
Amphibians-Frogs	*Osteopilus septentrionalis*	Cuban treefrog	Low	Hitchhiker on landscape material in Ohio
Crustaceans-Copepods	*Tachidius triangularis*	a copepod	Low	In Michigan, insufficient information for further prioritization
Crustaceans-Crayfish	*Faxonius obscurus*	Allegheny crayfish	Low	In Lake Ontario
Fishes	*Alosa aestivalis*	Blueback herring	Low	In Lake Ontario, native to east coast United States
Fishes	*Cyprinella analostana*	satinfin shiner	Low	In Lake Ontario, native to east coast United States
Fishes	*Enneacanthus gloriosus*	bluespotted sunfish	Low	In Lake Ontario, native to East Coast United States
Fishes	*Fundulus heteroclitus*	mummichog	Low	In Detroit, Mich., native to east coast United States
Fishes	*Monopterus cuchia*	cuchia	Low	In Mich., insufficient information for further prioritization
Fishes	*Morone chrysops* x *Morone americana*	white bass x white perch	Low	Hybrid in Lake Erie
Fishes	*Oncorhynchus aguabonita*	golden trout	Low	Stocked
Fishes	*Oreochromis aureus*	blue tilapia	Low	Escaped captivity in Ohio, does not typically tolerate temperatures below 8 ° Celsius
Fishes	*Salvelinus alpinus*	Arctic char	Low	In Lake Ontario, failed stocked
Mollusks-Gastropods	*Elimia virginica*	Piedmont elimia	Low	In Lake Erie Basin, native to east coast United States
Mollusks-Gastropods	*Gillia altilis*	buffalo pebblesnail	Low	In Lake Erie, native to east coast United States
Plants	*Limnobium spongia*	frogbite	Low	In Lake Ontario, native to southern and east coast of United States
Plants	*Pluchea odorata*	sweetscent	Low	In Mich., prefers brackish waters
Plants	*Solidago sempervirens*	seaside goldenrod	Low	In Lake Michigan, prefers higher salinity habitats
Platyhelminthes	*Dugesia polychroa*	a flatworm	Low	In Lake Ontario, minimal impact where introduced
Crustaceans-Copepods	*Mesocyclops pehpeiensis*	a copepod	Moderate	In Lake Erie and Lake St. Clair, no indication of invasiveness
Crustaceans-Copepods	*Salmincola californiensis*	gill lice	Moderate	In Lake Ontario, infect steelhead trout
Crustaceans-Crabs	*Eriocheir sinensis*	Chinese mitten crab	Moderate	In Lake Erie
Insects	*Acentria ephemerella*	(European) aquatic/ water moth	Moderate	In Lake Erie, no indication of invasiveness
Insects	*Tanysphyrus lemnae*	duckweed/ aquatic weevil	Moderate	In Lake Michigan, specific to duckweed

Table 8. Species not native to the Rainy-Lake of the Woods Basin, the Region (approximately 800-kilometer radius from the Rainy-Lake of the Woods Basin) or Great Lakes Basin, but occurring in the Great Lakes Basin, with the current priority for risk evaluation with comments and reasoning for the category.—Continued

[Information summarized from U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019; Agriculture Victoria, 2020; United Nations Educational, Scientific, and Cultural Organization, 2021]

Group	Scientific Name	Common Name	Priority for risk evaluation	Comment
Plants	*Carex disticha*	tworank sedge	Moderate	In Lake Huron, insufficient information for further prioritization
Plants	*Salix caprea*	goat willow	Moderate	In Mich., moderate impact on native species
Plants	*Schoenoplectiella mucronata* (*Schoenoplectus mucronatus*)	bog bulrush	Moderate	In Indiana, Ohio, Pennsylvania, Maryland, and Delaware
Platyhelminthes	*Scolex pleuronectis*	a cestode	Moderate	In Lake St. Clair, infects round goby
Protozoans	*Acineta nitocrae*	a suctorian ciliate	Moderate	In Lake Erie, minimal impact where introduced
Protozoans	*Psammonobiotus dziwnowi*	a testate amoeba	Moderate	In Lake Superior, Ontario, insufficient information for further prioritization
Protozoans	*Psammonobiotus linearis*	a testate amoeba	Moderate	In Lake Erie, insufficient information for further prioritization
Rotifers	*Brachionus leydigii*	a rotifer	Moderate	In Lake Erie, insufficient information for further prioritization
Crustaceans-Cladocerans	*Daphnia galeata galeata*	a waterflea	High-Approaching	In Lake Erie, hybridize with native species
Plants	*Marsilea quadrifolia*	European water clover	High-Approaching	In Michigan, can outcompete native species
Plants	*Sagittaria montevidensis montevidensis*	giant arrowhead	High-Approaching	In Lake Erie, may compete with native rice
Plants	*Salvinia minima*	water spangles	High-Approaching	In southeast United States, Missouri, Ohio, and California, “exponential growth rates.”
Plants	*Typha laxmannii*	graceful cattail	High-Approaching	In Milwaukee, Wisconsin, outcompetes native species where introduced
Protozoans	*Glugea hertwigi*	a microsporidian parasite	High-Approaching	In Lakes Erie and Ontario, infects exotic rainbow smelt, which may affect native salmonoids
Plants	*Carex acutiformis*	lesser pond sedge	Very High-Approaching	In Lake Michigan, may form dense thickets
Plants	*Hydrocharis morsus-ranae*	European frogbit, common frogbit	Very High-Approaching	In Lake Michigan, can form dense floating mats
Plants	*Stratiotes aloides*	water soldiers	Very High-Approaching	In Ontario, Lakes Huron, Erie, and Ontario, likely to crowd out native species

species categorized as Very High-Approaching are plants that are able to form dense mats and crowd out native species (U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019; Agriculture Victoria, 2020). The High-Approaching plant species also are capable of outcompeting native species but are farther away and not as easily transported or spread (U.S. Geological Survey, 2012; National Oceanic and Atmospheric Administration, 2019).

Species Not Present in the Rainy-Lake of the Woods Basin, Great Lakes Basin, or Region

After all species present in the Rainy-Lake of the Woods Basin, the Great Lakes Basin, or the Region were categorized for priority of risk evaluation, the total was 809 species, with the majority being 422 fish species and 142 plant species. Of these species, only three were designated as High-Approaching: *Procambarus virginalis* (marbled crayfish), *Filinia cornuta*, and *Filinia passa*. The marbled crayfish has not yet been found in the wild but is a common aquarium pet (U.S. Geological Survey, 2019). The reason for the elevated priority is that this crayfish is able to produce fertilized eggs via parthenogenesis, which means all marbled crayfish are females and lay eggs that are already fertilized without sperm (U.S. Geological Survey, 2012). Because of this unique ability, even one marbled crayfish released from an aquarium could produce a viable population to become established in the wild. The other two species, *Filinia cornuta* and *Filinia passa*, are rotifers that, although not yet present in the Great Lakes Basin, have been found in ballast tanks within the Great Lakes Basin. Nineteen species were designated as Moderate based on either proximity or potential to be introduced as being native to or currently in similar climates as the Rainy-Lake of the Woods Basin. The remaining 787 species are currently categorized as Low priority for risk evaluation. Many of these species are tropical, native to areas within North America, or currently confined to coastal basins; however, they could pose a threat to the Rainy-Lake of the Woods Basin in the future (U.S. Geological Survey, 2012, 2019; National Oceanic and Atmospheric Administration, 2019; Centre of Agriculture and Biosciences International, 2021; University of Georgia - Center for Invasive Species and Ecosystem Health, 2021). All the species not yet found in the Rainy-Lake of the Woods Basin, the Region, or Great Lakes Basin have been determined to be nonindigenous, and those that have probable vectors for introduction may warrant additional attention by stakeholders.

Final Priority for Risk Evaluation Lists and Conclusions

After evaluation of each species in the current database, 20 were identified as Very High-Present. Most of these species are plants (13) and may necessitate additional evaluation for their effect on native vegetation, especially wild rice as a culturally significant food crop (table 9). Several species, such as spiny water flea and cattails, have already had detrimental impacts on the food webs and native species in the Rainy-Lake of the Woods Basin. Because these species are present, many of the possible risks have already been realized, but the Aquatic Invasive Species Subcommittee might consider addressing these species during the early stages of risk evaluations.

Fifty species were designated as Very High-Approaching, with plants again accounting for the majority (19) (table 10). All the species are within a reasonable proximity to expect that they will arrive and become established in the Rainy-Lake of the Woods Basin via human, wildlife, or natural dispersal. Additionally, they have proven to be disruptive to the ecosystems into which they have been introduced by altering the food web, introducing disease, and causing habitat changes such as erosion or increased flooding (U.S. Geological Survey, 2012). Several States and Provinces have regulations on selling or trading these species to slow the spread, but some of these species are microscopic hitchhikers on recreational boats, waders, wildlife, or even wind. Education on strategies and practices to minimize spread and early detection to remove these species may be key to eradication as they encroach on the Rainy-Lake of the Woods Basin.

Based on proximity, ease of transport, or introduction and known impact to the Rainy-Lake of the Woods Basin or other impacted ecosystems, the 10 highest priority species identified for risk evaluations were *Bythotrephes longimanus* (spiny waterflea), *Faxonius rusticus* (rusty crayfish), *Neogobius melanostomus* (round goby), *Dreissena polymorpha* (zebra mussel), *Bithynia tentaculata* (mud bithynia, faucet snail), *Potamopyrgus antipodarum* (New Zealand mud snail), *Butomus umbellatus* (flowering rush), *Iris pseudacorus* (yellow flag iris), *Myriophyllum spicatum* (Eurasian watermilfoil), and *Phragmites australis australis* (common reed) (table 11). All but the round goby, New Zealand mudsnail, and starry stonewort are already present in the Rainy-Lake of the Woods Basin. These species are in adjacent watersheds, so may be present in the Rainy-Lake of the Woods Basin but not yet reported. All 10 highest priority species are nonindigenous and highly invasive. They are prolific reproducers, have no natural predators, outcompete native species, and can quickly decimate a local aquatic ecosystem. Going forward, the International Rainy-Lake of the Woods Multi-Agency Arrangement Aquatic Invasive Species Subcommittee can review the tables provided in this document to prioritize additional species to be further evaluated, focusing on five risk factors: arrival risk, vulnerability assessment, ecological impact, socioeconomic impact, and beneficial impact. Using the questions contained within the flow chart (fig. 2), the Subcommittee can determine the cumulative risk each species poses to the Rainy-Lake of the Woods Basin.

Table 9. Species designated as Very High-Present Priority for risk evaluation within the Rainy-Lake of the Woods Basin.

Group	Scientific name	Common name
Crustaceans-Cladocerans	*Bosmina coregoni*	a water flea
Crustaceans-Cladocerans	*Bythotrephes longimanus**	spiny waterflea
Crustaceans-Crayfish	*Faxonius rusticus**	rusty crayfish
Mollusks-Bivalves	*Dreissena polymorpha**	zebra mussel
Mollusks-Gastropods	*Bithynia tentaculata*	mud bithynia, faucet snail
Mollusks-Gastropods	*Cipangopaludina chinensis*	Chinese mysterysnail
Mollusks-Gastropods	*Viviparus georgianus*	banded mysterysnail
Plants	*Butomus umbellatus**	flowering rush
Plants	*Iris pseudacorus*	yellow iris, yellow flag iris, paleyellow iris
Plants	*Lythrum salicaria*	purple loosestrife
Plants	*Myriophyllum spicatum**	Eurasian watermilfoil
Plants	*Persicaria hydropiper*	marshpepper knotweed
Plants	*Phragmites australis australis**	common reed
Plants	*Potamogeton crispus*	curly-leaf pondweed, curly-leaved pondweed
Plants	*Rumex longifolius*	door-yard dock
Plants	*Rumex obtusifolius*	bluntleaf dock
Plants	*Sparganium erectum*	simplestem bur-reed
Plants	*Trapa natans*	water chestnut
Plants	*Typha angustifolia*	narrow-leaved cattail, narrow-leaf cattail
Plants	*Typha* X *glauca*	white cattail

*Species identified as part of the top 10 invasive species that could be prioritized first for risk evaluations based on their proximity, ease of transport or introduction, and known impact to Rainy-Lake of the Woods or other impacted ecosystems.

Table 10. Species designated as Very High-Approaching priority for risk evaluation within the Rainy-Lake of the Woods Basin.

Group	Scientific name	Common name
Bacteria	*Piscirickettsia* cf. *salmonis*	muskie pox
Bacteria	*Renibacterium (Corynebacterium) salmoninarum*	bacterial kidney disease (BKD), Dee disease
Birds	*Cygnus olor*	mute swan
Coelenterates-Hydrozoans	*Cordylophora caspia*	freshwater hydroid
Crustaceans-Amphipod	*Echinogammarus ischnus*	scud
Crustaceans-Amphipod	*Gammarus tigrinus*	tiger scud
Crustaceans-Cladocerans	*Cercopagis pengoi*	fishhook waterflea
Crustaceans-Cladocerans	*Daphnia lumholtzi*	waterflea
Crustaceans-Cladocerans	*Diaphanosoma fluviatile*	cladoceran
Crustaceans-Copepods	*Neoergasilus japonicus*	parasitic copepod
Crustaceans-Crayfish	*Procambarus clarkii*	Red Swamp Crayfish
Crustaceans-Mysids	*Hemimysis anomala*	bloody red shrimp
Fishes	*Ctenopharyngodon idella*	grass carp
Fishes	*Ctenopharyngodon idella* var. *diploid*	grass carp (diploid)
Fishes	*Gymnocephalus cernua* (*Gymnocephalus cernuus*)	ruffe
Fishes	*Morone americana*	white perch
Fishes	*Neogobius melanostomus**	round goby
Fishes	*Proterorhinus semilunaris*	freshwater tubenose goby
Mollusks-Bivalves	*Corbicula fluminea*	Asian clam
Mollusks-Bivalves	*Dreissena bugensis*	quagga mussel
Mollusks-Bivalves	*Dreissena* sp.	dreissenid mussel
Mollusks-Bivalves	*Sphaerium corneum*	European fingernail clam
Mollusks-Gastropods	*Cipangopaludina japonica*	Japanese mysterysnail
Mollusks-Gastropods	*Potamopyrgus antipodarum**	New Zealand mud snail
Mollusks-Gastropods	*Valvata piscinalis*	European stream valvata
Plants	*Carex acutiformis*	lesser pond sedge
Plants	*Cirsium palustre*	marsh thistle
Plants	*Conium maculatum*	poison-hemlock
Plants	*Egeria densa*	Brazilian waterweed
Plants	*Frangula alnus*	glossy buckthorn
Plants	*Glyceria maxima*	reed mannagrass
Plants	*Hydrocharis morsus-ranae*	European frogbit, common frogbit
Plants	*Impatiens glandulifera*	ornamental jewelweed
Plants	*Juncus compressus*	roundfruit rush
Plants	*Lysimachia nummularia*	creeping jenny
Plants	*Lysimachia punctata*	large yellow loosestrife
Plants	*Lysimachia vulgaris*	garden loosestrife
Plants	*Mentha* X *gracilis*	gingermint
Plants	*Myriophyllum aquaticum*	parrot feather
Plants	*Nasturtium officinale*	watercress
Plants	*Nitellopsis obtusa**	starry stonewort
Plants	*Nymphoides peltata*	yellow floating-heart
Plants	*Rorippa sylvestris*	creeping yellowcress (keek)

Table 10. Species designated as Very High-Approaching priority for risk evaluation within the Rainy-Lake of the Woods Basin.—Continued

Group	Scientific name	Common name
Plants	*Stratiotes aloides*	water soldiers
Platyhelminthes	*Ichthyocotylurus pileatus*	digenean fluke
Platyhelminthes	*Leyogonimus polyoon*	Leo
Protozoans	*Heterosporis sutherlandae*	microsporidian parasite
Protozoans	*Myxobolus cerebralis*	salmonid whirling disease
Viruses	*Novirhabdovirus* sp. genotype IV sublineage b	Viral Hemorrhagic Septicemia Virus (VHSV-IVb)
Viruses	*Ranavirus*	largemouth bass virus (LMBV)

*Species identified as part of the top 10 invasive species that could be prioritized first for risk evaluations based on their proximity, ease of transport or introduction, and known impact to Rainy-Lake of the Woods or other impacted ecosystems.

Table 11. Top 10 priority species for risk evaluation for the Rainy-Lake of the Woods Basin.

Group	Scientific name	Common name
Crustaceans-Cladocerans	*Bythotrephes longimanus*	spiny waterflea
Crustaceans-Crayfish	*Faxonius rusticus*	rusty crayfish
Fishes	*Neogobius melanostomus*	round goby
Mollusks-Bivalves	*Dreissena polymorpha*	zebra mussel
Mollusks-Gastropods	*Bithynia tentaculata*	mud bithynia, faucet snail
Mollusks-Gastropods	*Potamopyrgus antipodarum*	New Zealand mudsnail
Plants	*Butomus umbellatus*	flowering rush
Plants	*Iris pseudacorus*	yellow iris, yellow flag iris, paleyellow iris
Plants	*Myriophyllum spicatum*	Eurasian watermilfoil
Plants	*Phragmites australis australis*	common reed

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